



Tropospheric column ozone response to ENSO in GEOS-5 assimilation of OMI and MLS ozone data

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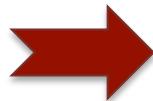
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Why do we care about this?

Tropospheric ozone is significant to:

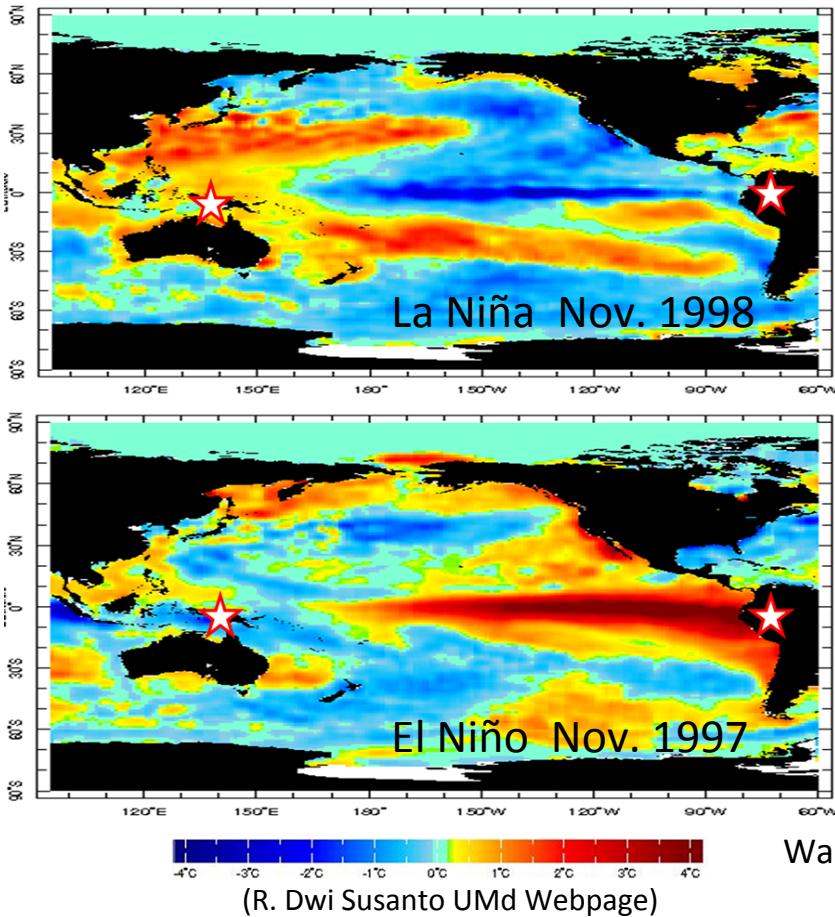
- Air quality
- Climate
- Tropospheric chemistry

Tropospheric ozone has both natural and anthropogenic sources

 *Need to quantify sources of natural variability to assess present and future anthropogenic influence.*

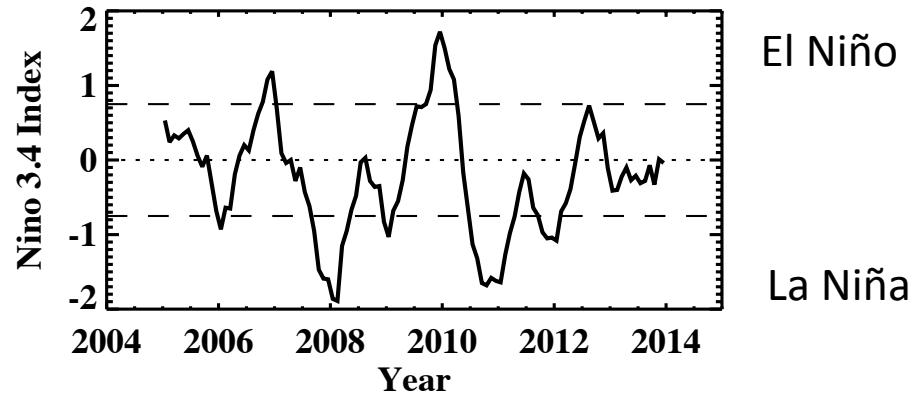
Tropical Ozone Response to ENSO

- There have been numerous studies focused on the tropical tropospheric ozone response.



Niño 3.4 Index

Based on the mean tropical sea surface temperature between 5° N – 5° S and 170° W – 120° W.



Warmer SSTs → greater upward motion → less trop. column ozone

There are seemingly contradictory results of extratropical ozone response

- Some studies find significant tropospheric ozone response in middle latitudes
 - Broad midlatitude regions (Oman et al., JGR, 2013)
 - Colorado ozonesonde data (Langford et al., GRL, 1998, 1999)
- However, others do not find a significant response over extratropical regions
 - Sonde and model analysis of large midlatitude regions (Hess et al., ACPD, 2014)
 - FTIR data from 8 subtropical and extratropical NDACC sites (Vigouroux et al., ACP, 2015)

Goal of This Study

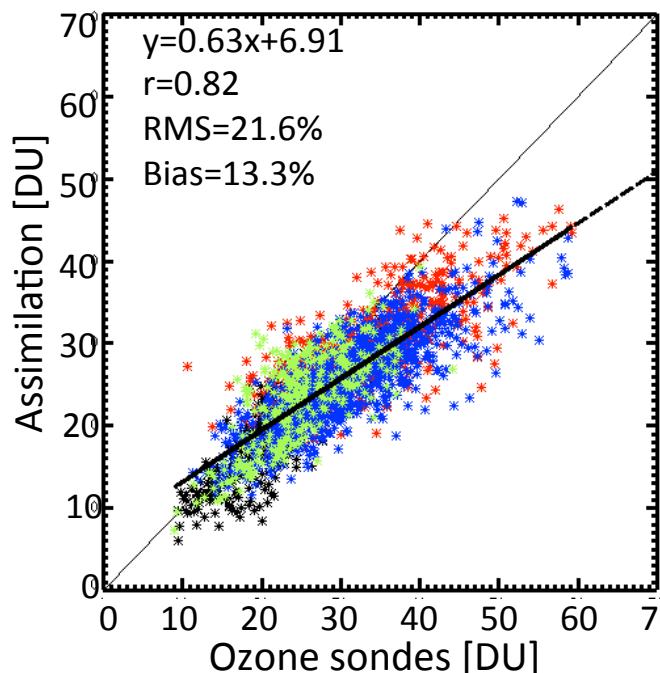
Investigate the magnitude, spatial distribution, and mechanisms of the ENSO influence on tropospheric column ozone (TCO) using GEOS-5 analyses of OMI and MLS data.

The Data Assimilation System

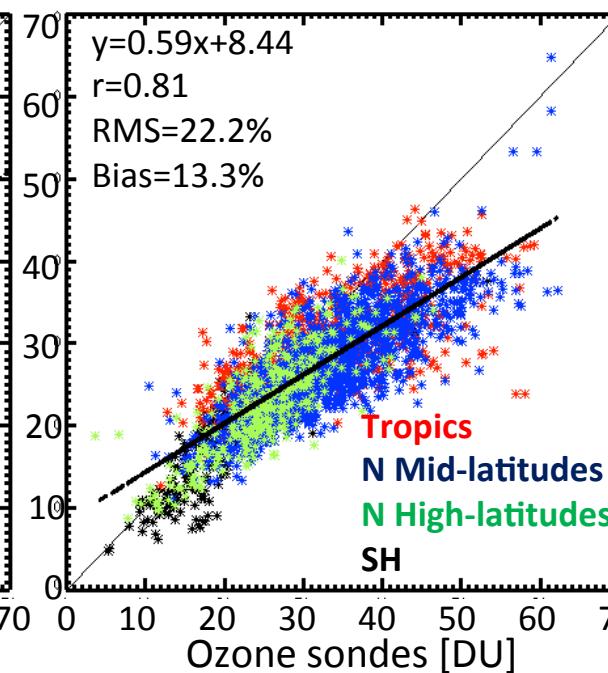
- We assimilate total column ozone from OMI and stratospheric profiles from MLS (both onboard Aura) into GEOS-5
- Ozone is assimilated alongside meteorological data
- Model resolution: $2^\circ \times 2.5^\circ$ Lat-Lon for this analysis
- Analysis spans 2005 through 2013
- Ziemke et al. (2014) and Wargan et al. (2015) evaluate the assimilated tropospheric ozone

Tropospheric column ozone (TCO) agrees well with sondes

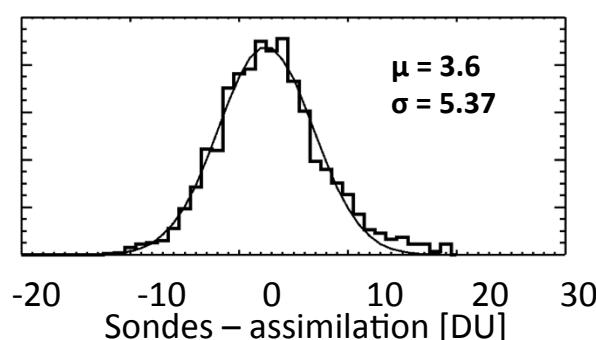
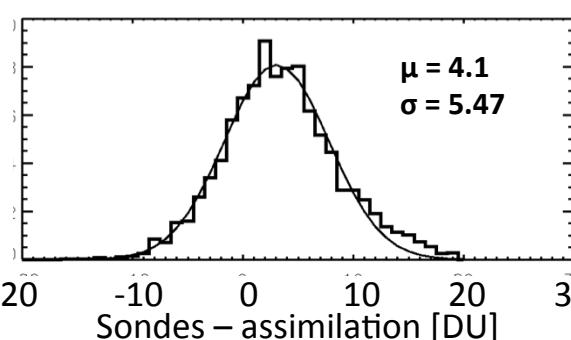
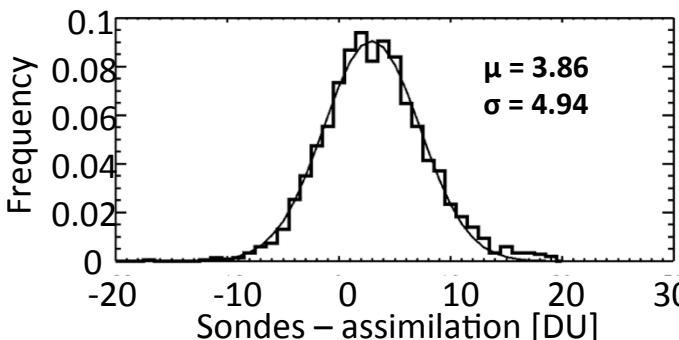
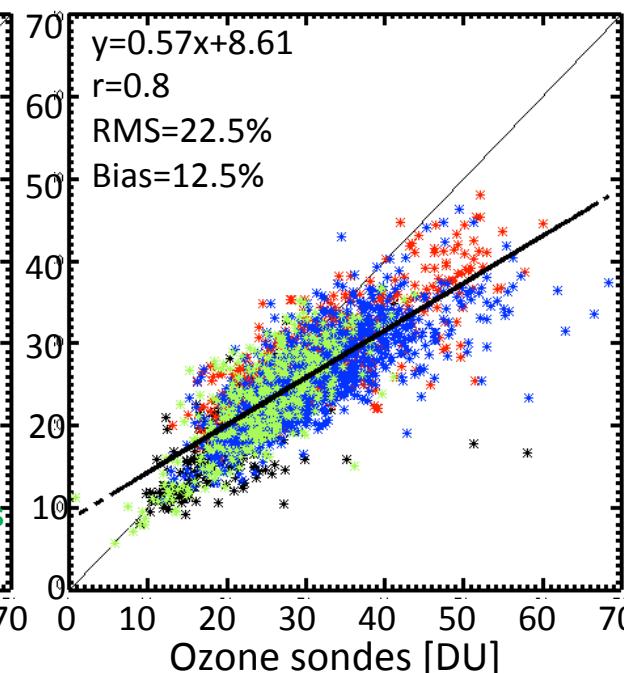
Surface – 2PVU, 2005



Surface – 2PVU, 2006



Surface – 2PVU, 2007



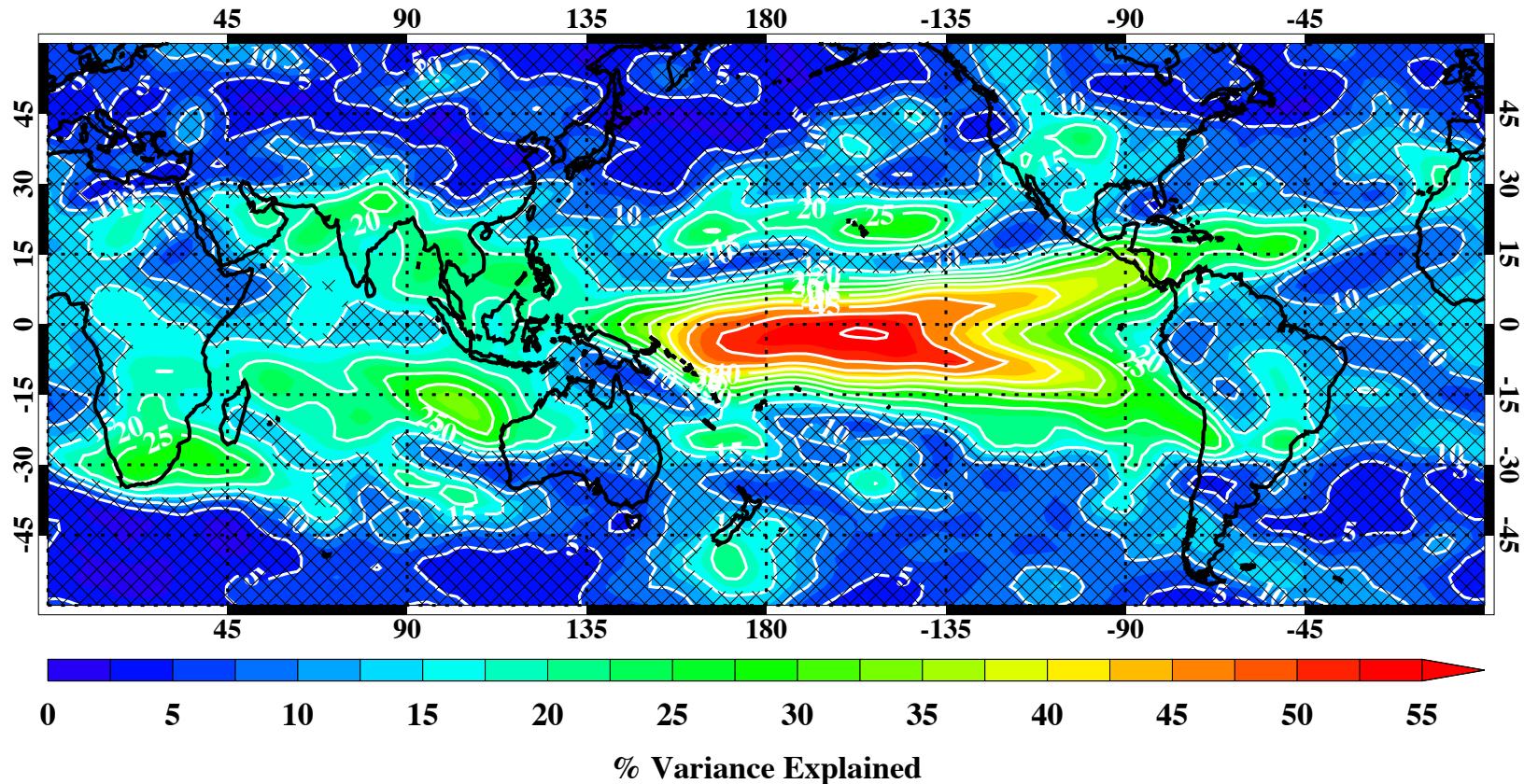
Assimilation is biased low, globally 3.6 – 4.1 DU. The bias is latitude dependent but does not vary much from year to year.

Correlation with sondes: ~0.8

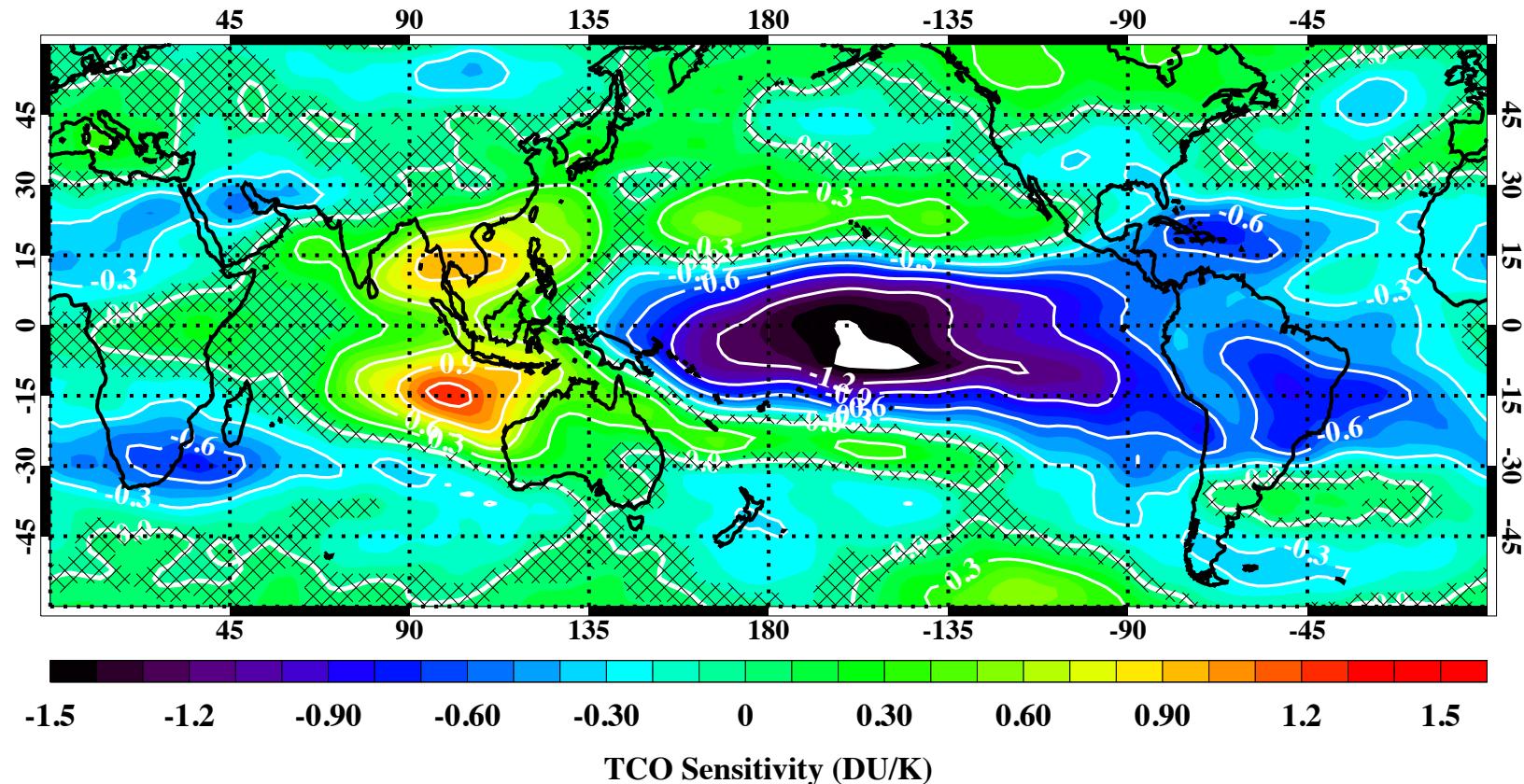
We use regression analysis of ENSO influence

- Use monthly mean TCO from the assimilation.
- Deseasonalize by removing interannual monthly means at every grid point.
- Regressed on monthly ENSO index (Niño 3.4) at every grid point.

Percent Variance Explained

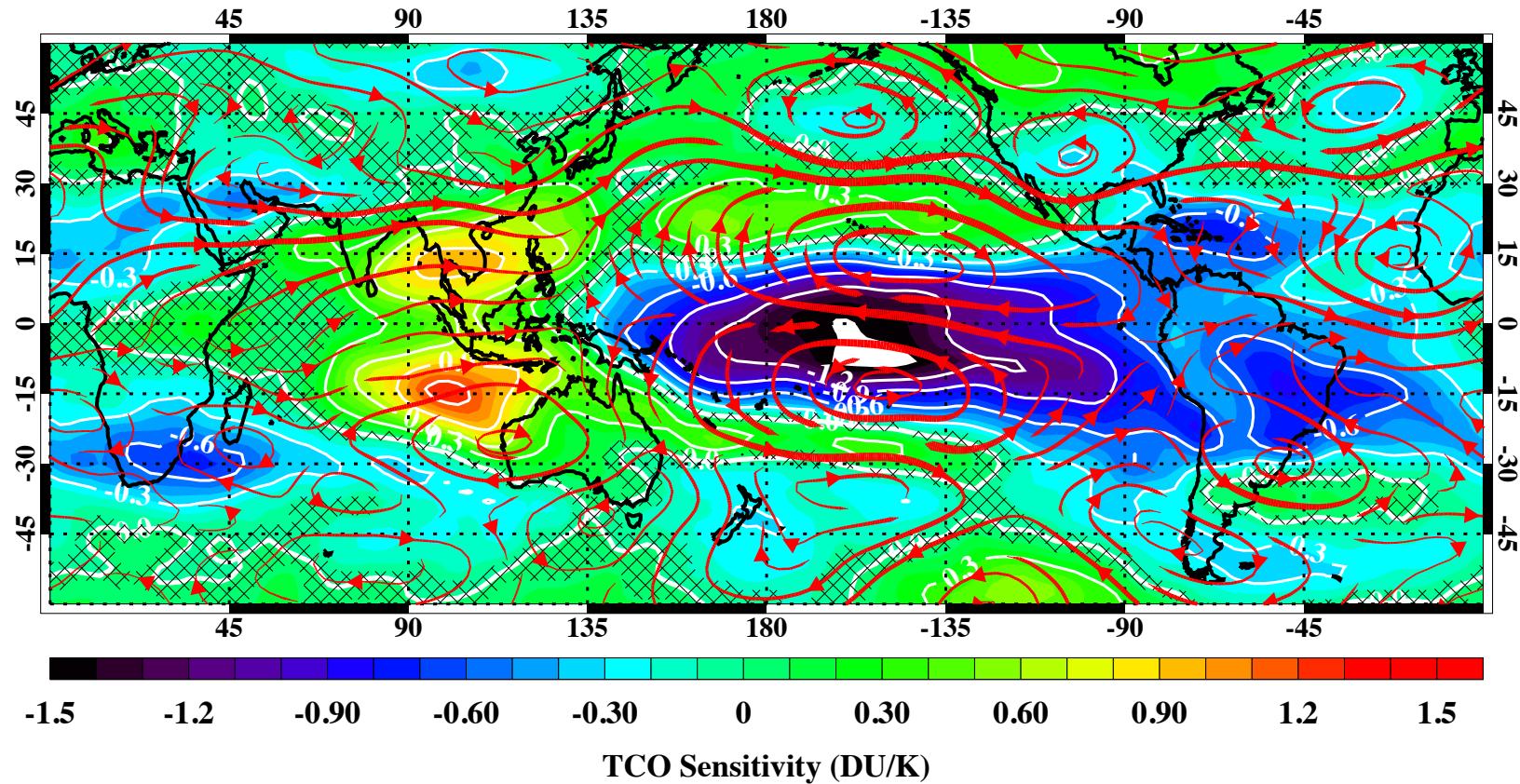


TCO Sensitivity (DU/K)

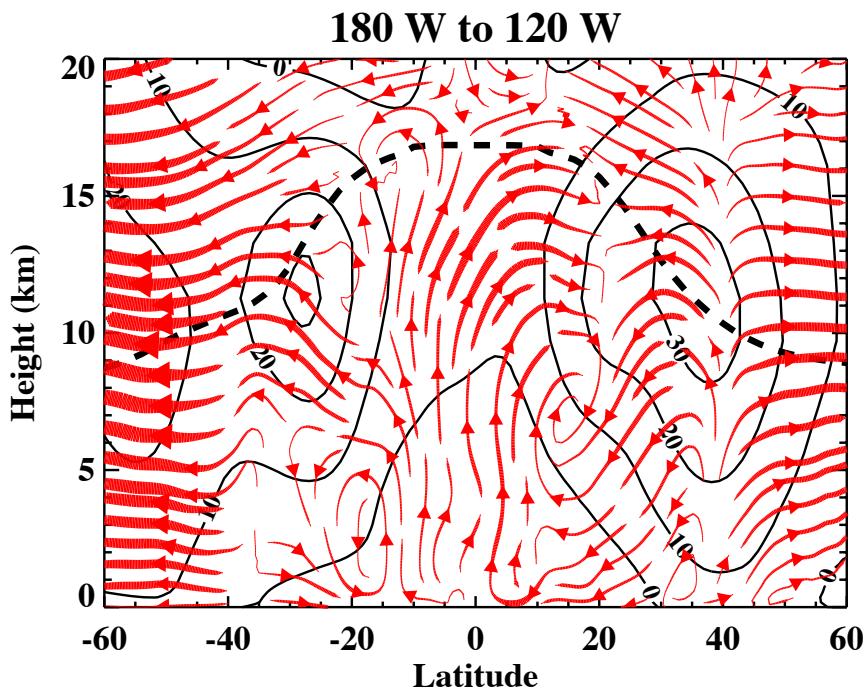


TCO Sensitivity And Wind Differences

(Wind Diff.: mean of months with index greater than 0.75 – mean of months with index less than -0.75)
(Strong El Niño – Strong La Niña)



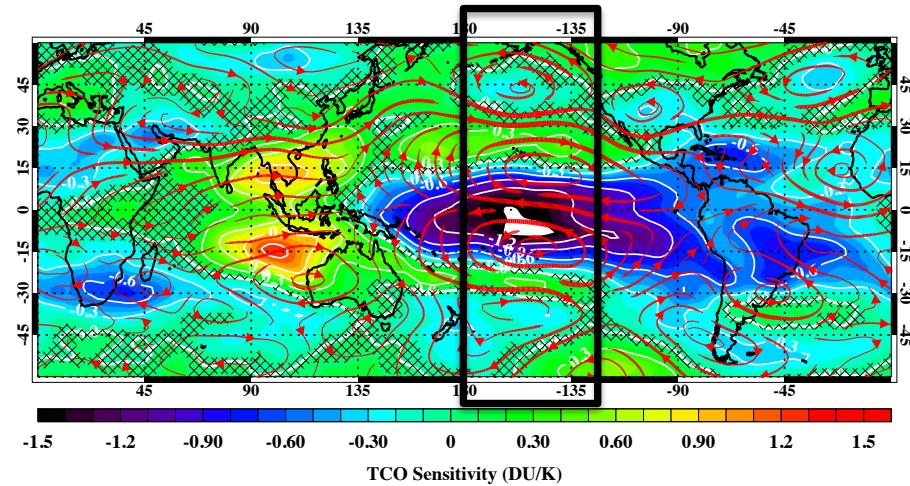
Vertical and meridional winds are consistent with sign of sensitivity



Red streamlines: Difference in winds from Strong El Niño and La Niña

Solid black contours: Mean zonal winds

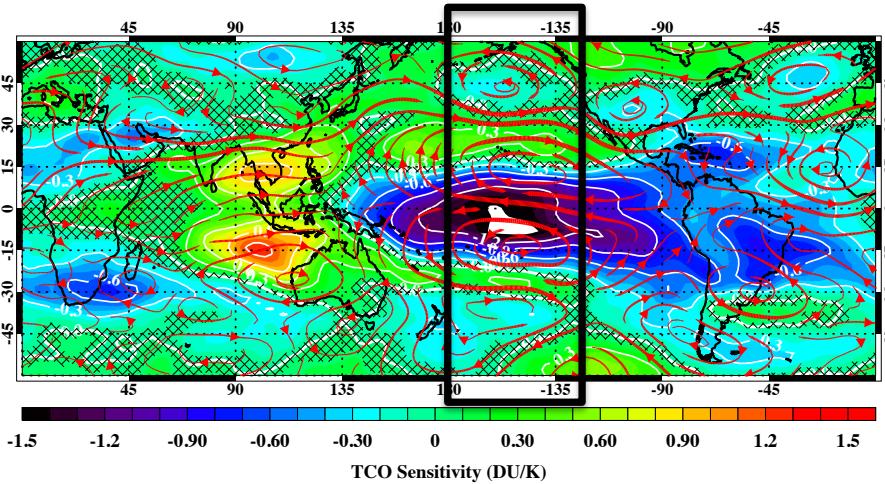
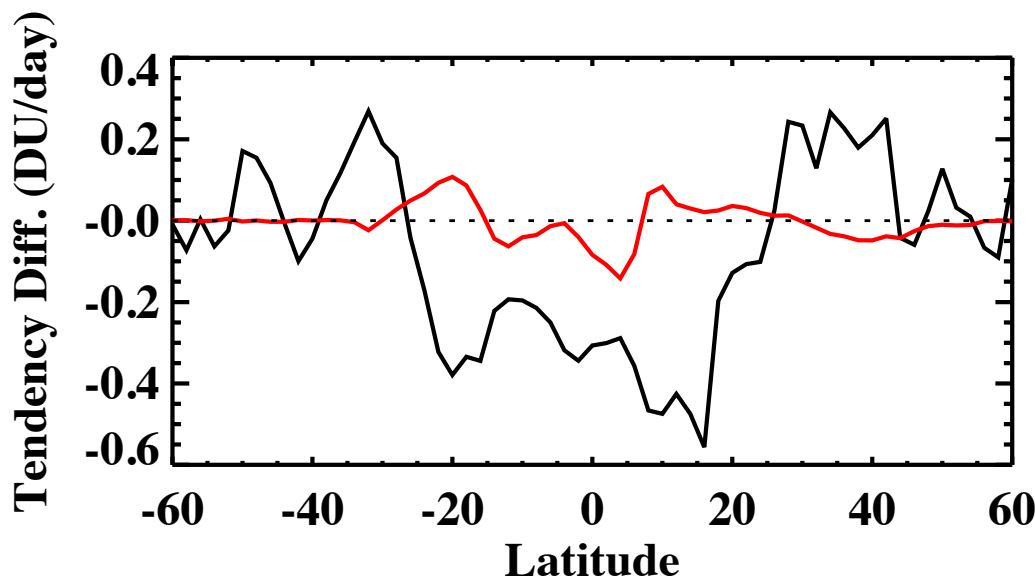
Heavy dashed contour: Mean tropopause



Advection tendencies dominate convection

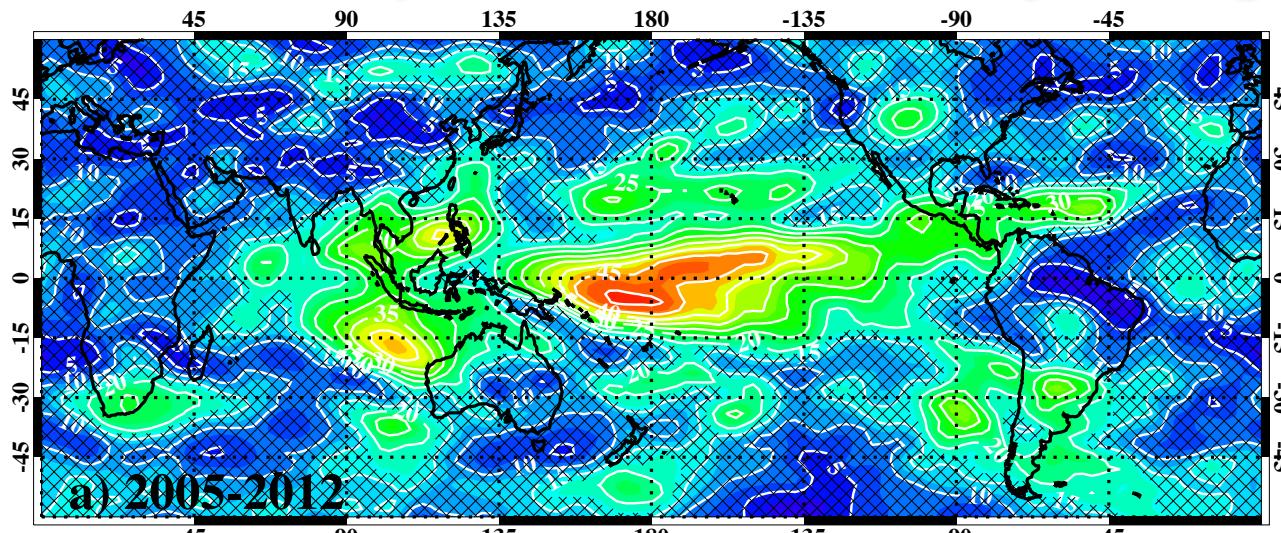
Tendency differences
between strong El Niño
and strong La Niña months

Advection
Convection

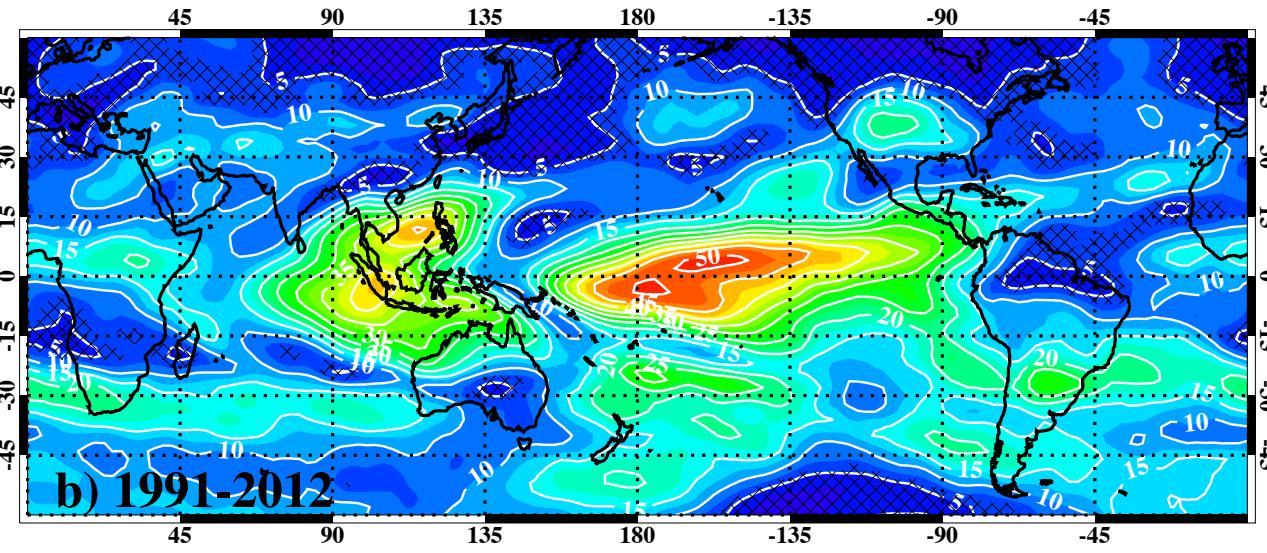


Are results representative of longer term?

GMI
(2005-2012)

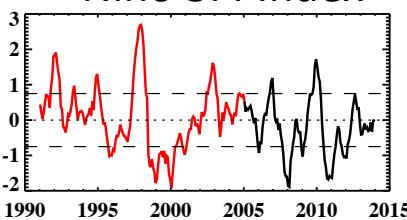


GMI
(1991-2012)



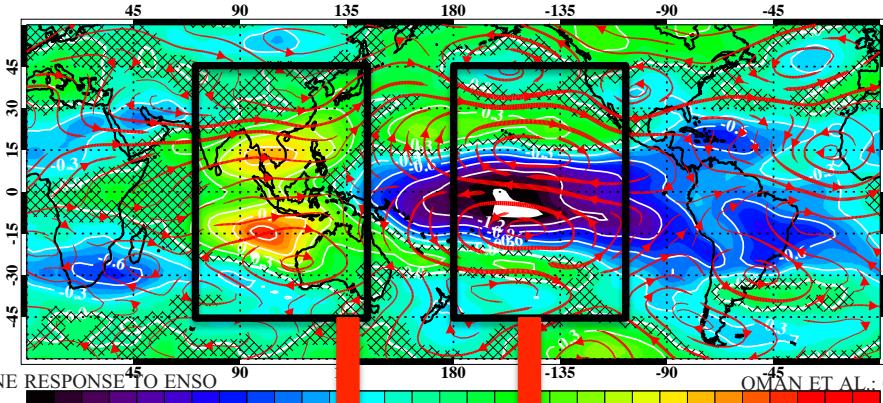
Variance Explained

Niño 3.4 Index



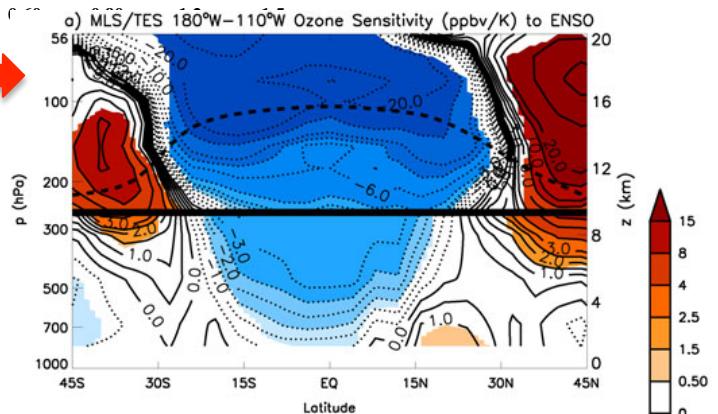
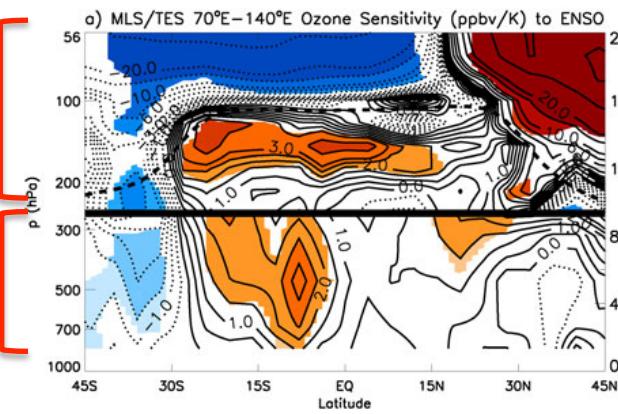
Revisiting Prior Studies

Oman et al. (2013) evaluated the ozone response using MLS and TES data.

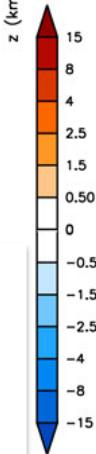


Sensitivity

MLS
TES

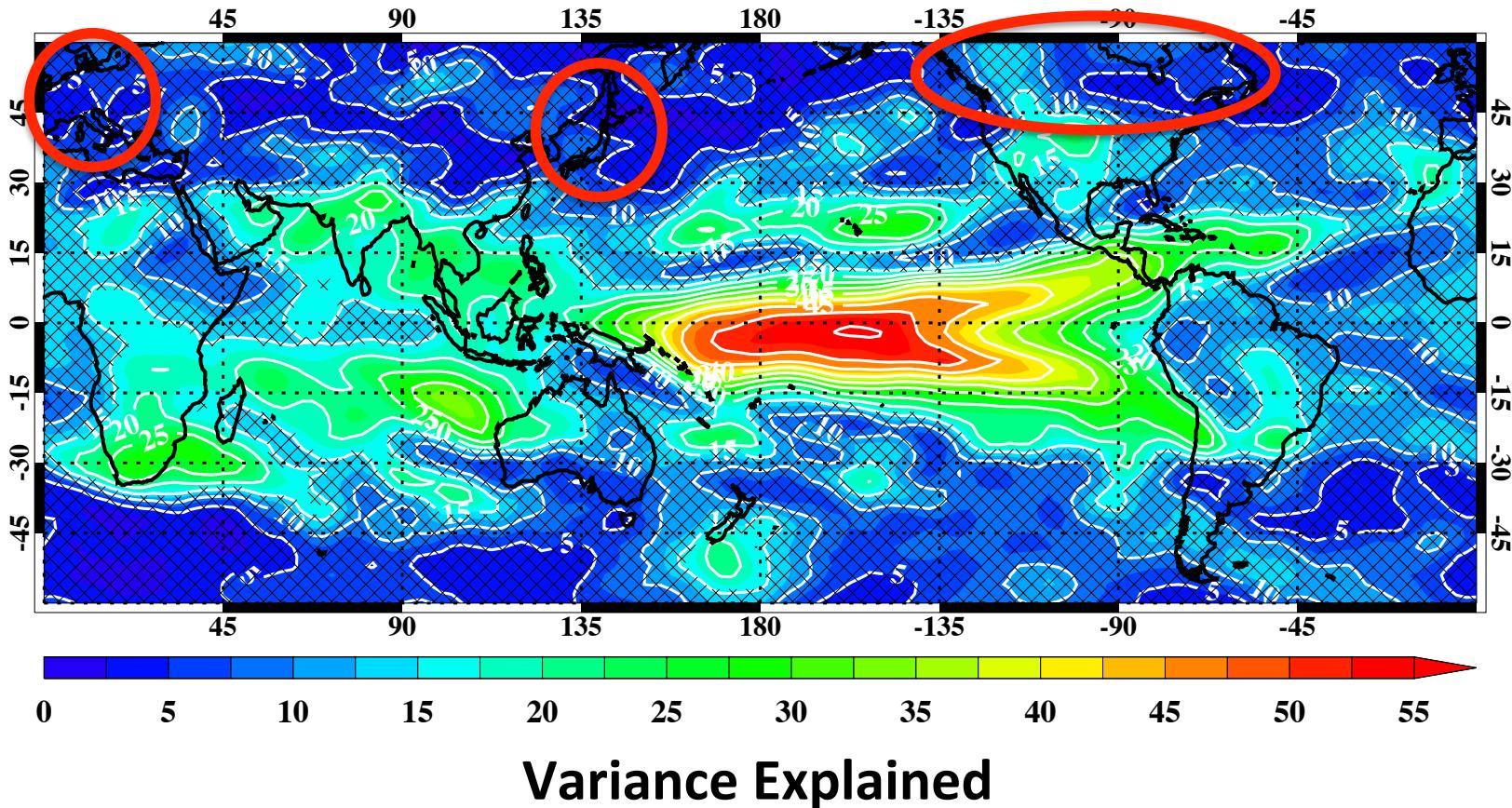


(Mean cross-sections in boxes above)



Revisiting Prior Studies

Hess et al. (2015) did not find ENSO influence in sonde data averaged over three extratropical regions.



Summary

- Assimilation enables this first comprehensive study of the tropical and midlatitude response of TCO to ENSO along with the ancillary information to interpret the results.
- Tropics: agrees well with prior studies. Two-lobe structure identified in western Pacific.
- Midlatitudes: response is relatively weaker but significant over small regions. Results unify the seemingly disparate findings in prior studies that are limited by distribution and sparseness of available data.
- Results are useful as a process-oriented assessment of model simulations.